7the Symposium on Frequency Standards and Metrology Summary Submission for oral presentation.

Compensated Multi-pole Mercury Trapped Ion Frequency Standard and Stability Evaluation of Systematic Effects

E.A. Burt, J.D. Prestage, and R.L. Tjoelker
Jet Propulsion Laboratory, California Institute of Technology
Pasadena, CA 91109-8099, U.S.A.
Email: eric.a.burt@jpl.nasa.gov

We have developed a compensated multi-pole Linear Ion Trap Standard (LITS) that eliminates nearly all frequency sensitivity to residual ion number variations. When operated with ^{199}Hg, this trapped ion clock has recently demonstrated extremely good stability over a 9-month period. The short-term stability of this clock has been measured at $5\times10^{-14}/\tau^{1/2}$ and an upper limit on fractional frequency deviation of $<2.7\times10^{-17}$/day was measured in comparison to the laser-cooled primary standards and to the post-processed ultra-stable version of TAI known as TTBIPM using GPS carrier phase time transfer [1].

In this paper we will describe: 1) key technological aspects of this standard, including ion-number-dependent second-order Doppler shift compensation; 2) results from the recent 9-month comparison; 3) a stability evaluation performed on the clock during the 9-month comparison, which revealed background gas pressure as the primary source of clock instability (the top six systematic sensitivities are temperature-dependent second-order Doppler shift: $-1.5(3.4)\times10^{-17}$/day, collision shift due to neon buffer gas: $-1.1(0.6)\times10^{-17}$/day, collision shift due to other UHV background gases: $<0.9\times10^{-17}$/day; number-dependent second-order Doppler shift: $-0.84(0.23)\times10^{-17}$/day, second-order Zeeman shift due to the electron beam filament: $-0.35(0.14)\times10^{-17}$/day, and the Hg/Hg+ collision shift: $-0.22(0.40)\times10^{-17}$/day); 4) a first measurement of the Hg/Hg+ collision shift, which is one of the limiting clock systematics; and 5) a new getter-only sealed vacuum manifold for the clock aimed at improving vacuum pressure stability.

Further study of long term systematic effects when the clock is operated with only a getter vacuum system is underway to verify stability limitations that may be expected in miniature or vacuum tube based ion clocks such as those being developed for space applications*.

[1] E.A. Burt, W.A. Diener, and R.L. Tjoelker, accepted for publication in the IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control.
